Does Hedging Increase Firm Value?

Evidence from Oil and Gas Producing Firms

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Abstract

I investigate whether hedging materially increases firm value by examining whether the hedging premium is higher when firms hedge a large, primary risk as compared to a small, secondary risk – as would be expected if hedging causally increases firm value by decreasing deadweight costs caused by volatile earnings or cash flows. Using a sample of oil and gas exploration and production (E&P) firms that hedge commodity price for my analysis, I find that amongst undiversified E&P firms, where commodity price is a primary risk, hedging is associated with *lower* firm value. In contrast, for diversified firms with an E&P segment, where commodity price is a secondary risk, hedging is associated with *higher* firm value. Further, I find that hedging primary (secondary) risk is a proxy for bad (good) management or high (low) agency costs. Once these factors are taken into account, the valuation effects associated with hedging become insignificant. Taken together, these results suggest that the effect of hedging on firm value, if any, is marginal.

Keywords: hedging, firm value, corporate governance

1 Introduction

Should a firm's hedging policy affect its value? In a classical Miller-Modigliani world, a firm's hedging activities are irrelevant in determining firm value. However, in real financial markets, firms face a variety of frictions, such as financial distress and bankruptcy costs, taxes, costly external financing, incomplete contracting and asymmetric information. Risk management theory posits that the deadweight cost caused by these frictions decreases if a firm's cash flow volatility is reduced. Therefore, hedging increases firm value by decreasing cash flow volatility. I refer to this hypothesis as the *costly volatility hypothesis*.[1]

An important question for academics and practitioners alike is whether the increase in firm value caused by hedging is significant. Several recent papers that examine this issue conclude that the increase is indeed significant, with the estimated hedging premium being as high as 40% (see Allayannis and Weston (2001), Allayannis, Lel and Miller (2003), Bartram et al. (2003), Carter et al. (2004) and Graham and Rogers (2002)).[2] However, in most existing empirical studies, the risks hedged, such as forex or interest rate risk, are not primary risks but are secondary risks.[3] As Guay and Kothari (2003) show, managing such secondary risks only has a small impact on a firm's cash flows. So, the source of the increase in firm value that is attributed to hedging in the extant literature is not obvious.

This paper makes two contributions to the literature. First, I provide a new test for

[1]I define hedging as the use of financial instruments to reduce the magnitude of the exposure of a firm's cash flows to a set of risks. Different theories focus on frictional costs caused by the volatility of different financial characteristics. However, as a practical matter, reducing cash flow volatility will generally reduce the frictional costs associated withe the volatility of other financial variables of interest.

[2]This literature is discussed in greater detail in Section 2.

[3]The fact that firms are exposed to large, primary risks and small, second-order secondary risks is well-documented. For example, in a clinical examination of a US firm with significant foreign operations, Brown (2001) finds that industry returns factor, a proxy for primary business risk, is highly significant in explaining the firm's stock returns whereas foreign currency exchange rates, a proxy for secondary risk, is not.

the costly volatility hypothesis. Unlike the extant literature, I first disaggregate the risk exposures into *primary* risks that have a significant impact on a firm's financial condition and *secondary* risks that only have a small, second-order impact and then separately analyze the valuation impact of hedging each type of risk. If hedging causes firm value to increase, hedging a primary risk should result in a larger premium as compared to hedging a secondary risk, because the resulting decrease in cash flow volatility and therefore in frictional costs will be greater. By comparing the difference between the valuation effects of hedging primary versus secondary risks, I provide new evidence regarding whether hedging causally affects firm value. Second, in light of the Guay and Kothari critique, I also test an alternate hypothesis. I posit that hedging does not causally increase firm value. Rather, the apparent valuation effect is simply because hedging is a noisy proxy for other factors not previously considered in the literature when analyzing the effect of hedging on firm value. I refer to this hypothesis as the *aliasing hypothesis*. I test the aliasing hypothesis by proposing a candidate set of such omitted factors and then examining whether the hedging premium changes once I control for these factors.

I test the hypotheses using a sample of oil and gas E&P (exploration and production) firms that are exposed to commodity price risk. I hand collect data for the years 1999 - 2000, and augment this with data from 1992 - 94 from Haushalter's (2000) sample to form a dataset of 364 firm-years. This sample is particularly well-suited to test whether the relationship between hedging and firm value changes with hedging a primary versus a secondary risk because there is considerable cross-sectional variation in exposure to commodity price risk across the firms. I classify this risk as a primary or secondary risk for a firm based on the fraction of revenues derived from its E&P operations. For firms that derive at least 80% of their revenues from E&P, I classify commodity price risk as a primary risk, and label these firms as pure-play firms. For the balance of the sample, I classify this risk as a secondary risk and label these firms as diversified firms. While most of my tests are based on commodity price risk, for the sub-sample of the 1999-2000 pure-play firms, I also collect data on interest rate derivatives use to conduct a robustness test.

To estimate the effect of hedging on firm value, I closely follow the methodology used in the literature. I regress a measure of firm value (Tobin's Q) on a measure for hedging (fraction of next year's production hedged against falling commodity prices), with the regression coefficient on the hedging variable being interpreted as the effect of hedging on firm value.

If hedging increases firm value, as posited by the costly volatility hypothesis, firms that hedge a primary risk should trade at a significant premium relative to non-hedgers. However, I find the opposite. Hedging primary risk is associated with a significant *discount* of about 15%. However, hedging secondary risk is associated with a significant *premium* of about 30%. These valuation effects are robust to controlling for several factors previously identified in the risk management literature that might correlate a firm's hedging policy and its value, such as: growth options, financing constraints, leverage, firm size, and profitability.

Given that I find evidence contrary to the costly volatility hypothesis, I next examine whether the data supports the aliasing hypothesis. While there are several possible reasons why hedging and firm value might be spuriously correlated, I test whether hedging is a proxy for agency conflicts and managerial skill. I use institutional and insider ownership, and the corporate governance index developed by Gompers et al. (2003) to construct proxies for agency costs between managers and shareholders, and develop two indexes based on production information and capital structure to develop proxies for managerial quality. Consistent with the aliasing hypothesis, once I control for these factors, hedging is no longer significant in explaining firm value. My results suggest that hedging primary (secondary) risk is a proxy for bad (good) management and/or high (low) agency conflicts.

What are possible economic rationales for these factors being common drivers for hedging policy and firm value? Consider first the apparent premium for hedging secondary risks found in this paper and in the extant literature. In firms with good governance, I speculate that managers hedge secondary risks as a disciplining mechanism to ensure that actual market data is used for internal budgeting decisions, as suggested by Brown (2001). Alternately, good managers might hedge secondary risks so that outside investors can easily separate out the effect of good management from favorable movements in market risk factors. Since such hedging is a noisy proxy for managers working in the interests of shareholders – the real source of higher firm value – hedging a secondary risk appears to significantly increase firm value. However, once I explicitly control for good governance, the premium for hedging secondary risk is no longer significant.

Next consider the apparent discount for hedging primary risk. In an extractive industry, such as oil and gas exploration, investment opportunities are likely to be correlated with commodity prices. In firms with potentially large manager-shareholder conflicts, managers might be engaging in a range of value-destroying activities. For example, managers might hedge to ensure funding is available for their pet projects as suggested by Tufano (1998). Consistent with this hypothesis, I find firms that hedgers are less productive than non-hedgers and have more expensive reserves. Similar to the case for secondary risk, once I explicitly control for managerial quality and agency conflicts, the discount for hedging primary risk is no longer significant in explaining firm value.

The rest of the paper is laid out as follows: In Section 2, I review the literature. In Section 3, I provide an illustrative example to motivate why hedging primary risks should have a significantly larger impact on firm value as compared to secondary risks. I discuss the hypotheses and the data in Section 4. In Section 5, I test the costly volatility hypothesis, and conduct some additional robustness tests in Section 6. In

Section 7, I test the aliasing hypothesis. In Section 8, I compare empirical estimates of a particular benefit of hedging with numerical estimates derived from a calibrated model. Finally, Section 9 concludes.

2 Literature Review

Risk management theories motivate hedging as a means to increase firm value by reducing the deadweight costs caused by various market frictions.[4] Scholars have used two approaches to empirically examine whether hedging increases firm value.

The first approach indirectly tests whether hedging increases firm value bye examining whether the cross-sectional variation in firms' hedging policies is consistent with firms hedging to reduce frictional costs. The hedging policy is the left-hand variable, and various proxies for frictional costs are the explanatory variables. A large body of papers have used this approach, across a wide spectrum of samples. Using a sample of large US corporations exposed to foreign currency risk, Geczy et al. (1997) conclude that hedging is used to reduce costly external financing costs. Lewent and Kearney (1990) come to a similar conclusion in their clinical study of Merck's hedging practices. In a more recent paper Haushalter (2000), examines the determinants of hedging commodity price risk using a sample of 100 oil and gas E&P firms. He finds that the extent of hedging is positively associated with leverage, consistent with the firms hedging to reduce financial distress and bankruptcy costs. I use some of his data for my analysis.

Other papers, however, find conflicting evidence. For example, in a study examining hedging gold price risk by gold producing firms, Tufano (1996) concludes

[4] Detailed summaries of these theories can be found in several of the empirical papers that examine the determinants of a firm's hedging policy, such as Graham and Rogers (2002), Haushalter (2000), Geczy et al. (1997), and Mian (1996). For an excellent discussion on the various motivations for hedging and additional reviews of the empirical support for different theories, see Grinblatt and Titman (1998).

that "virtually no relationship exists between risk management and firm characteristics that value-maximizing risk management theories would predict". Brown (2001) conducts a clinical study on forex derivatives use at "HDG" (pseudonym), a large durable goods manufacturer with business activities in 50 countries. He concludes that "several commonly cited reasons for corporate hedging are probably not the primary motivation for why HDG undertakes a risk management program". Recent papers document that factors unrelated to financing frictions , such as agency costs, are important determinants of a firm's hedging policy. For example, in a sample of ADR-listed firms Lel (2003) finds that corporate governance variables are significant in explaining a firm's hedging decision, whereas proxies for frictional costs, such as leverage, are not. Given the mixed empirical findings from papers using this approach, it is difficult to conclude that the primary motivation for hedging is to increase firm value. Adam et al. (2004) aptly summarize papers using this approach by observing that "the cross-sectional correlation between firm-specific characteristics, suggested by theory, and hedging practices is relatively weak."

The second approach, increasingly used in recent papers, directly tests whether hedging is a significant explanatory variable for firm value. Here, a measure of firm value is the left-hand variable, and hedging is a right-hand explanatory variable. The hedging premium is estimated as the regression coefficient on the hedging variable. I use this approach in my paper. This approach was first used by Allayannis and Weston (2001). They use Tobin's Q as the proxy for firm value and an indicator variable for foreign currency derivatives use as the proxy for hedging. Using a sample of large US non-financial firms with foreign sales, they conclude that hedging increases firm value by 3- 8%.[5] Using a sample of airline companies, Carter et al. (2004) conclude

[5]Allayannis and Weston estimate the hedging premium using several different controls and estimation methodologies, which results in different point estimates of the hedging premium. They assume that the use of forex derivatives is a proxy for risk management activity within the firm, so that the hedging premium reflects the premium for risk management rather than simply the benefit from hedging foreign currency risk.

that hedging increases firm value by 12 - 16%, which they attribute to reduced costly external financing costs. In an international sample of 7,000+ firms Bartram et al. find that hedging is associated with higher firm value only for certain risks, such as interest rate risk.

The results of studies using the second approach suggest that hedging significantly increases firm value. However, these papers focus on hedging small, secondary risks, such as forex, interest rate or fuel price risk. As Guay and Kothari (2003) show, hedging such secondary risks can only have a minor impact on a firm's volatility.[6] Using a sample of 234 large, non-financial US corporations, Guay & Kothari examine the economic significance of a firm's hedging portfolio. Even under the extremely scenario of a simultaneous 3 standard deviation movement in the underlying risk factors (likelihood of the order of 1 in one billion) they find that the payout from the hedging portfolio is modest compared to either the level or the volatility of a firm's cash flows.[7] The median value of the payout is just $15 MM, while the median cash flow from operations is $178 MM, and three-year maximum absolute change is $104 MM. They conclude that "derivatives use appears to be a small piece of non-financial firms' overall risk profile. This suggests a need to rethink past empirical research documenting the importance of firms derivative use."

In light of the conflicting findings of the studies using the first approach, and the Guay and Kothari critique of studies using the second approach, it is an open question as to whether hedging increases firm value. This paper makes two contributions to the literature in this area. First, I provide a new test for the hedging-increases-firm-value

[6]Even fuel costs, which might seem like a major expense, make up only 13% of a typical airline's operating costs. The results of Brown (2001) suggests that foreign exchange risk is a secondary risk even for firms with extensive foreign operations, and the effect of foreign exchange fluctuations on a firm's financial position is swamped by changes in primary risk factors, such as industry-specific risk.

[7]Guay and Kothari focus on interest rate, foreign currency and commodity derivatives. I estimate the likelihood assuming these risks are three independent normal random variables. If there are only two independent factors, the likelihood is still only of the order of 1 in one million.

hypothesis by differentiating between the valuation effects of primary and secondary risks.[8] Second, I test an alternate hypothesis. Given the positive association documented between a firm's hedging policy and factors unrelated to frictional costs, I examine whether the apparent valuation effects attributed to hedging are because hedging is a proxy for other factors known to markedly affect firm value.

3 Illustrative Example - Exposure to Primary versus Secondary Risks

As compared to other studies on corporate risk management, this paper differentiates between primary and secondary risks. To motivate why this distinction is important, I contrast how a firm's financial condition changes with a change in its primary versus secondary risks. For the example, I focus on two firms from my sample, Mission Resources and Resource America. Mission Resources is solely in the business of oil and gas exploration and production, and commodity price is a primary business risk for this firm. In contrast, Resource America is also active in several other businesses, such as real estate and leasing. Its E&P segment contributes only 18% of total revenues, and commodity price is a secondary risk for this firm. Between the years 1999 and 2000, the annual average of oil and gas prices rose by 65%. I exploit this significant increase to serve as a natural experiment to estimate how the change in

[8] The literature often assumes that the hedging policy of a secondary risk is a good proxy for hedging primary risks. This is a strong assumption, and to my knowledge, has never been empirically tested. In my sample, I find that the extent of hedging primary and secondary risks is not correlated. I conduct the test using the sub-sample of pure-play firms from 1999 - 2000 for which I have collected data on interest rate derivatives use. I examine whether hedging commodity price risk is correlated with hedging interest rate risk, the secondary risk in this sample. I use the fraction of next year's production hedged against commodity price volatility as the proxy for hedging the primary risk and the notional amount of interest rate derivatives normalized by total assets as the proxy for hedging secondary risk. Several papers, including Graham and Rogers (2002) and Purnanandam (2003) also use this measure as their proxy for hedging. To control for exposure, I restrict the sample to observations with a non-trivial level of debt (debt-to-assets ratio ≥ 0.1). I find that the correlation between the two hedging measures is 0.11 and statistically insignificant, with a p-value of 0.25.

commodity prices – a primary risk for one firm and a secondary risk for the other – changes their respective financial conditions.

In Table 1, I report how the cash flow from operations and net income changes for these two firms between 1999 and 2000. The increase in commodity prices leads to a dramatic improvement in the financial position of Mission Resources. Its cash flow from operations increases by almost 60%, and net income by over 260%. In contrast, for Resource America, the effect is much more modest. Cash flow from operations increases by only 10%, and net income is virtually unchanged. These results suggest that a change in a primary risk has a first-order impact, whereas a change in the secondary risk only has a second-order impact on a firm's financial position. Clearly, if hedging is to measurably decrease the frictional costs associated with volatile earnings or cash flows, a firm needs to hedge its primary rather than its secondary risks.

4 Hypothesis Development and Data

In this Section, I describe my empirical strategy to test the costly volatility and aliasing hypothesis.

If, as posited by the costly volatility hypothesis, hedging causes firm value to increase, the increase should be larger when firms hedge a primary versus a secondary risk. To test this hypothesis, I assemble a dataset where risks can be meaningfully classified as primary or secondary, and examine whether the premium is greater for hedging primary versus secondary risks. I use a sample of oil and gas producing firms for my analysis, with most of my tests based on commodity price risk. The sample and the criteria used to classify commodity price as a primary or secondary risk is described in greater detail later.

I closely follow the methodology used in the extant literature to estimate the hedging premium by regressing firm value on my measure for hedging. That is, I estimate a model of the form:

$$firm\ value = \beta_{hedging} * hedging\ proxy + \beta_X * X + \varepsilon \quad (1)$$

Here, X is a set of controls for factors considered in the literature to correlate a firm's hedging policy and its value.[9] The regression coefficient on the hedging proxy, $\beta_{hedging}$, is the estimated hedging premium. My measure of firm value is Tobin's Q, defined as: (market value of common shares plus book value of total assets less book value of common shares)/book value of total assets. Most of my tests are based on hedging commodity price risk. My primary measure of hedging is the fraction of next year's production hedged against a drop in commodity prices. For a robustness test, I also conduct tests based on hedging interest rate risk.

Following the literature, I control for firm size, profitability, leverage, credit rating, financing constraints, level of exposure to the hedged risk, and growth options.[10] (See Allayannis and Weston (2001), Allayannis, Lel and Miller (2003) and Bartram et al. (2003) for a discussion on the theoretical motivations for controlling for these factors). Financing constraints and growth options are considered particularly important determinants of a firm's hedging policy as well as its value. Therefore, as a

[9]Throughout the paper, X includes a vector of ones, so that the constant in the regression is included in the $\beta_X * X$ term.

[10]All the studies referenced in Section 2 that directly test whether hedging is a significant explanatory variable for firm value control for these factors to a certain extent. The exact proxy used for these factors varies across studies. For example, Allayannis and Weston (2001), who use a broad cross-industry sample, use advertising and R&D expenses to proxy for growth options. However, Bartram et al. (2003), who also use a multi-industry sample, do not. These variables are not meaningful proxies in my sample. Bartram et al. only control for the level of exposure to forex and interest rate risk, but not for commodity price risk, although they examine all three risks. Allayannis & Weston control for credit rating using seven dummies for debt ratings, whereas Bartram et al. and Carter et al. don't include any control for this factor. Only about one-third of firms in my sample have credit ratings. Accordingly, I construct a ratings index that equals +1 for firms with superior rating, 0 for unrated firms, or firms with average rating and -1 for firms with inferior rating. This index provides a meaningful way to control for both – variation in credit ratings as well as whether a firm is rated or not. Bartram et al. also control for country effects, whereas Allayannis & Weston do not, although 15% of their sample consists of firms incorporated outside the US.

robustness check, I use several different proxies for these two factors to check whether my findings are sensitive to the particular choice of control used. To proxy for financing constraints, I use a common dividend dummy and the Kaplan-Zingales index (See Fazzari et al. (1988), Kaplan and Zingales (1997), Alti (2003) and Moyen (2003) for a discussion about the use of these variables as proxies for financing constraint). To proxy for growth options, I use capital expenses scaled by total assets. As a robustness check, I also scale capital expenses by net sales. Since valuations for E&P versus non - E&P businesses might differ for reasons specific to the business segment, I also include the fraction of revenues from the E&P segment as a control. To control for time effects, I use dummy variables for each calendar year. The definition of the various controls used is provided in Table 2. I defer discussion about the agency cost controls to Section 7.1.

To test the aliasing hypothesis, I repeat the regressions performed for testing the costly volatility hypothesis, but include additional controls. That is, I now estimate a model of the form:

$$firm\ value = \beta_{hedging} * hedging\ proxy + \beta_X * X + \beta_Z * Z + \varepsilon \tag{2}$$

where X is the original set of controls used when testing the costly volatility hypothesis, and Z is a set additional controls for corporate governance, agency costs and managerial quality. I defer discussion of these controls to Section 7.1.

I use a sample of oil and gas producing firms to conduct my analysis. The data for this study comes from two sources. First, I select firms identified as oil and gas producers based on their 4-digit SIC code of 1311 in the COMPUSTAT database for the year 2000, and for which the annual report or 10-K s are available electronically. After an initial screening, I eliminate firms with total assets less than $20 Million and those incorporated in countries other than the US, Canada or the Cayman Islands because data on their hedging policy or other required information is often not reported. I then manually read the annual reports of these firms and hand collect commodity hedging data for the years 1999 and 2000. If a firm does not provide sufficient information to estimate the amount of production hedged, I drop the firm-year from my dataset. This yields 157 firm-years of usable data. In addition to commodity hedging data, I also collect data on interest rate derivatives use, firm ownership (from the SEC Def-14A filings, the Thomson Financial database, and proxy statements) and select operating characteristics, such as reserves and production information.

I construct my measure of hedging commodity price risk by dividing the quantity of next year's production hedged against a drop in commodity prices divided by the expected production for the next year. The quantity hedged is the sum of the net notional amounts of the various derivatives contracts used for hedging, such as forwards, collars or options, plus the quantities effectively hedged through long-term fixed price delivery contracts. I use the current year's production as the proxy for the next year's production.[11] Carter et al. (2004) and Haushalter (2000) use a similar approach in computing the hedging proxy. Next, I augment my sample with data used in Haushalter (2000). Although his paper also examines hedging practices of oil and gas producers, our papers differs in two important ways. First, I focus on the valuation effects of hedging. Second, I distinguish between firms where commodity price is a primary risk, and firms where it is a secondary risk. I use 207 of his firm-year observations, using the same selection criteria as I did for my firms (size $>$ \$20 MM, publicly traded, not missing any major data items). Firms in his sample are also identified as oil and gas producers based on their 4-digit SIC code. Haushalter collects his hedging data for public source such as annual reports as well as from a confidential survey. His sample is for the years 1992 - 1994. In addition, I collect

[11] For the few firms in my sample that have experienced significant ($\pm 50\%$) growth or contraction during the year, I scale the current year's production by the change in total assets to estimate next year's production.

the Gompers-Ishii-Metrick corporate governance index for the entire dataset, and use it to construct the managerial entrenchment dummy. I describe the index and the dummy in greater detail in Section 7.

My final sample consists of 364 firm-year observations. It is an unbalanced panel, consisting of 125 firms. Only 14 firms are present in all years and for several firms I only have a single observation. During my sample time period, oil prices rose during the years 1992, 1993 and 2000, and dropped during 1994 and 1999. I test whether my results are driven by the bear versus bull markets in Section 6.2.

Summary statistics are presented in Table 3. Panel A presents statistics for the entire sample, and Panels B and C for the sub-samples of pure-play and diversified firms, respectively.

As seen from Table 3, Panel A, E&P revenues range from 10% to 100% of total revenues. This considerable variation commodity price to be meaningfully classified as a primary risk for some firms and a secondary risk for other firms, and I can test the costly volatility hypothesis using this sample. I classify this risk as a primary risk for firms that derive 80% or more of their revenues from production, and label these firms as pure-play firms. For the rest of the firms, I classify this risk as a secondary risk and label them diversified firms. I address whether my results are sensitive to the classification scheme in a series of robustness tests.

Approximately two-thirds of the firms hedge some of their commodity price risk. Amongst the hedgers, the average fraction hedged is 30% for pure-play firms and 23% for diversified firms. The extent of hedging is comparable to that documented in other studies. For example, in his sample of gold mining firms, Adam (2002) finds that the median fraction of gold price risk hedged is 38%. Also, as seen in Panel B, the pure-play firms are high-growth firms, with capital expenses for the median firm equalling 19% of assets. Therefore, if hedging markedly reduces the underinvestment costs, as Carter et al. (2004) suggest, hedgers should trade at a significant premium relative to non-hedgers in this sub-sample.

5 Testing the Costly Volatility Hypothesis

In this Section, I test the costly volatility hypothesis by examining whether the premium for hedging primary risk is greater than for hedging secondary risk. With the exception of the results in Section 6.3, for all of the results reported in the paper, *hedging* refers to the hedging of commodity price risk. I use log(Tobin's Q) as the dependent variable in the firm value tests since the log-transform provides a natural way to interpret the results. For example, in univariate tests, a difference of x translates directly into a difference in firm value of x %, and in multivariate tests, a coefficient of β on the hedging variable directly translates into a premium of β% for hedging the entire production.

5.1 Univariate Tests

I first perform a t-test on the pure-play and diversified firm sub-samples. Recall that commodity price is a primary risk for the pure-play firms, and a secondary risk for the diversified firms. Therefore, by examining the hedging premium separately for these sub-samples, I obtain a first estimate of the premia for hedging primary and secondary risks. A firm is classified as a hedger if it hedges any of its exposure to commodity price risk, and as a non-hedger otherwise. Firm-years with a positive but trivial amount of hedging (<2%) are excluded.[12]

Table 4 compares the mean Q values for hedgers versus non-hedgers. Panel A presents results for hedging primary risk. Hedging such a risk is supposed to result in a significant positive premium. Instead, I find the opposite, with hedgers trading

[12] The results are qualitatively similar if trivial hedgers are retained, or if trivial hedgers are defined using a 5% cutoff.

at a significant *discount* of 12% relative to non-hedgers. This finding is in direct contrast to the earlier literature which finds a positive hedging premium. Panel B presents results for hedging secondary risk. Similar to earlier literature which finds a positive association between hedging a secondary risk and higher firm value, I also find a positive hedge premium of 25%. The negative premium for hedging primary risk and the positive premium for hedging a secondary risk is at odds with the costly volatility hypothesis.

5.2 Multivariate Tests

Following the literature, I next estimate the hedging premium by regressing firm value on hedging policy, controlling for a various factors considered to correlate a firm's value and its hedging policy.

5.2.1 Multivariate Tests - Pure-Play Firm Sub-sample

Since the negative hedging premium for primary risk is contrary to the positive premium documented in the literature, I first estimate the hedging premium for primary risk using only using observations for pure-play firms. Results for the entire sample are presented later. For the multivariate tests, the hedging variable is the fraction of next year's production that is protected against falling commodity prices. The model estimated is:

$$ln(Q) = \beta_p * production\ hedged + \beta_X * X + \varepsilon \tag{3}$$

where *production hedged* is the fraction of next year's production hedged, β_p is the associated premium for hedging this primary risk, and X is a set of controls. The regression results are shown in Table 5,

Even after including the various controls suggested in the literature, the hedging premium for primary risk remains negative and significant. For example, β_p for regression (1) is -0.171, which means that a firm that hedges all of its production for next year trades at a 17.1% *discount* relative to a similar firm that does not hedge at all. Additionally, for most of the control variables, the sign of the coefficient is consistent with theoretical priors and statistically significant.

As a robustness check, I examine whether the hedging premium is sensitive to the controls used by varying the proxies for financing constraints and growth options. In regression (2), I use the common dividends dummy as a control for financial constraints. The coefficient on the hedging variable is virtually identical (-0.163 versus -0.171). In (3), I use a non-financial measure to proxy for growth options, namely, the ratio of undeveloped to total reserves. Again, the hedging coefficient remains significantly negative. As a further robustness check, in unreported results, I also use debt-to-equity (instead of debt-to-liabilities) as an alternate proxy for leverage. The results are qualitatively similar.

5.2.2 Multivariate Tests - Full Sample

Next, I jointly estimate the premia for hedging primary and secondary risks using the full sample. In order to estimate both hedging premia, I need to estimate a model of the form:

$$ln(Q) = \beta_p * hedge_p + \beta_s * hedge_s + \beta_X * X + \varepsilon \tag{4}$$

where $hedge_p$ and $hedge_s$ are proxies for primary and secondary risk hedged, and β_p and β_s are the corresponding estimates of the hedging premia.

I construct these proxies by interacting the fraction of production hedged with a function that classifies commodity price as a primary or secondary risk for the firm. That is,

- $hedge_p$ = fraction of production hedged * f_p , and,
- $hedge_p$ = fraction of production hedged *f_s

where f_p and f_s are the classification functions used to represent whether commodity price is a primary risk or secondary risk for the firm. The functions used are graphed in Figure 1. I use several different classification functions to examine whether my results are particularly sensitive to how I define primary versus secondary risks. I construct f_p and f_s as functions of revenues derived from the E&P segment, denoted by $X_{E\&P}$. I use different functional forms for these functions to examine whether my results are overly sensitive to how exactly commodity price risk is classified as a primary or a secondary risk. The results of the regressions for the full sample are shown in Table 6.

One possible choice for [f_p,f_s] would be to define f_p as the indicator function: $I_{X_{E\&P}\geq 0.8}$, and f_s as its complement. That is, if revenues from oil and gas production make up at least 80% of total revenues, then commodity price is a primary risk for the firm, and otherwise a secondary risk. This is the same definition used to classify commodity price as a primary risk for the univariate analysis. However, with this choice of [f_p,f_s], a firm that derives even 79.99% of its revenues from commodity sales and hedges its commodity price risk would be classified as a hedger of secondary risk. To address this concern, for regression (1) I instead define f_s as:

$$f_s = I_{X_{E\&P}\leq 0.2} * 1 + I_{0.2<X_{E\&P}\leq 0.8} * \frac{0.8-(X_{E\&P})}{0.8-0.2} + I_{X_{E\&P}>0.8} * 0 \qquad (5)$$

The function is graphed in Figure 1. That is, for $X_{E\&P}$ below 0.8, commodity price is classified entirely as a primary risk and for $X_{E\&P}$ below 0.2, entirely as a secondary risk. However, for intermediate values, f_s decreases linearly from 1 at $X_{E\&P}$ = 0.2 to zero at $X_{E\&P}$ = 0.8. This functional form represents the intuition that for intermediate values of $X_{E\&P}$, commodity price cannot be distinctly classified as either a primary or a secondary risk. With this classification scheme, a firm with, say, $X_{E\&P} = 0.79$, is essentially classified as a non-hedger, regardless of its actual hedge position.

For regression (2), I use the same definition of f_s as for regression (1), but now define f_p as the complement of f_s. With this combination of [f_p,f_s], a firm with an intermediate value of $X_{E\&P}$, say, $X_{E\&P} = 0.5$, that hedges commodity price risk would be considered as having hedged some primary and some secondary risk. For regression (3), I define $f_p = X_{E\&P}$ and f_s as its complement. The various functional forms are graphed in Figure 1. In unreported results, I also use other functional forms for f_p and f_s. [13] The results are qualitatively similar.

I now also include f_p (and also f_s if it is not the complement of f_p) as controls to ensure that my results are not driven simply because of a non-linear relationship between Tobin's Q and $X_{E\&P}$, that is being captured by f_p or f_s. Also, for all regressions, I first normalize f_s and f_p to have a mean of unity for the diversified and pure-play firms, respectively, before constructing $hedge_p$ and $hedge_s$. With this normalization, the coefficients β_p and β_s can be interpreted as the hedging premia for a 'typical' firm that hedges it primary or secondary risk.

As seen from Table 6, similar to the results from the univariate tests, the premium for hedging secondary risk remains statistically and economically significant. For example, β_s in regression (1) is 0.267. This means that a 'typical' diversified firm that hedges its entire production for the next year will trade at a premium of 26.7% relative to a comparable firm that does not hedge at all. With the different definitions of f_p and f_s used, the coefficients for the hedging proxies change somewhat, however the main result is unaltered. Hedging primary risk continues to be associated with a discount, and hedging secondary risk with a premium. In unreported results, as

[13] Some of the other [f_p,f_s] pairs used include: [$f_p = I_{X_{E\&P} \geq 0.8}$, $f_s = I_{X_{E\&P} \leq 0.4} * 1 + I_{0.4 < X_{E\&P} \leq 0.8} * \frac{0.8-(X_{E\&P})}{0.8-0.4} + I_{X_{E\&P} > 0.8} * 0$], [$f_p = I_{X_{E\&P} \geq 0.8}$, $f_s = 1 - f_p$], and [$f_p = I_{X_{E\&P} \geq 0.7}$, $f_s = 1 - f_p$].

a robustness check I examined whether the results were particularly sensitive to the choice of proxies used as controls. I used the common dividends dummy as a proxy for financing constraints, and capital expenses normalized by sales (instead of assets) as a proxy for growth options. The results are qualitatively similar.

If hedging were to increase firm value, the premium for hedging primary risk should be significantly positive and larger than the premium for hedging secondary risk. However, I find contrary evidence in both, the univariate as well as the multivariate tests. The hedging premium for primary risk is significantly *negative*, while for hedging secondary risk is significantly positive (and obviously larger than the premium for hedging primary risk). These results make it difficult to support the hypothesis that hedging actually increases firm value. Rather, the data suggests that the association between hedging and firm value might be because hedging proxies for other factors which can have a marked impact on firm value. I defer this issue to Section 7 and first conduct some additional robustness checks in Section 6.

6 Robustness Checks

6.1 Accounting Methods

Oil and gas producing firms use two different accounting conventions to record exploration costs. Companies that use the full-cost method capitalize all costs related to acquire, explore for and develop oil and gas properties. In contrast, companies that use the successful efforts method charge off to expenses exploration costs for wells that are not commercially viable. Hence, *ceteris paribus*, firms that use the full-cost method will have a higher book value of total assets, and therefore a lower Tobin's Q, as compared to firms that use the successful efforts method. Since only pure-play firms will have significant exploration costs, this issue is relevant primarily for this sub-sample of firms. Amongst these firms if hedgers prefer to use the full-cost method of accounting, then hedgers will appear to trade at a discount simply because of their choice of accounting method. To examine whether the accounting method might explain the negative correlation between hedging and firm value for this sub-sample, I examine whether the accounting choice is correlated with either firm value or the fraction of production hedged. The correlations with either variable is essentially zero, suggesting that choice of accounting method cannot explain away the apparent hedging discount.[14] Between accounting choice and fraction of production hedged, $\rho = 0.054$ (p-value=0.432) and between accounting choice and firm value, $\rho = 0.008$ (p-value = 0.911).

6.2 Timing Effects

Hedging primary risk might be associated with lower firm value simply because of the mechanics of how hedging is performed and reported. Firms typically enter into contracts at different times during the current year to hedge production for the next year. I collect information on hedge positions and firm value at the end of the year. Hence, if commodity prices rise during the year, the hedge positions will lose value, and hedgers will trade at a discount simply because of the liability of their hedging portfolio. Conversely, if commodity prices drop during the year, hedgers will trade at a premium.

To investigate whether this mechanical effect is important, I examine whether the hedging premium is significantly different for years with rising versus falling prices. Based on a comparison of average versus year-end prices, oil price fell during the

[14] The accounting method is available from the COMPUSTAT data as a footnote item for the plant, property and expenses item. Only 214 valid observations are available for the sub-sample of pure-play firms. Given the insignificant correlations between the accounting method and either the hedging or the firm value proxy, collecting the missing accounting method data from sources other than COMPUSTAT does not seem warranted.

years 1992, 1993 and 2000, and rose during the years 1994 and 1999.[15] As this timing effect will be relevant only for firms with significant hedge positions, I compare the non-hedgers with firm-years that have hedged at least 30% of their production. This is the median fraction hedged amongst the pure-play firms that are hedgers. The results of the t-tests are reported in Table 7.

As seen in Table 7, firms that hedge trade at a significant discount regardless of whether prices rose or dropped, and the difference in the hedge discount is not significant across these two commodity price regimes. The most significant price rise was for 1999 (+35%), and price drop for 1993 (-22%). Even for 1993, when the mechanics of hedging should have resulted in a positive hedging premium, the premium is still -11%. This result suggests that the hedging discount for primary risk is not simply due to the mechanical timing effects.

6.3 Hedging a Secondary Risk Amongst Pure-Play Firms

The results presented Section 5 exploit the cross-sectional variation in the level of exposure to commodity price risk to classify this risk as a primary or secondary risk for the different firms. For the sub-sample of pure-play firms, interest rate risk is clearly a secondary risk compared to commodity price risk. For a sub-sample of my data (the years 1999 and 2000), I also collect data on interest rate derivatives, and repeat the firm value regressions for the pure-play firms using interest rate derivatives as the proxy for the firm's hedging policy. Following Faulkender (2002), I only consider derivatives used to swap debt instruments other than lines of credit.[16] In my sample this restriction results in swaps only being used to convert fixed debt to floating rate debt. Fixed-to-floating interest rate swaps are presumably used to hedge the

[15] The oil price used is West Texas Intermediate benchmark obtained from: `http://tonto.eia.doe.gov/oog/ftparea/wogirs/xls/psw13vdcr.xls`.

[16] Faulkender argues that since lines of credit can be easily retired or refinanced, it is difficult to gauge the extent of exposure to interest rate risk caused by these instruments.

risk associated with an increase in the liability of fixed rate debt if interest rates fall. Following Allayannis and Weston (2001) and Bartram et al. (2003), I use a 0-1 dummy for interest rate derivatives use as the hedging proxy and restrict my sample to firms with ex-ante exposure to the risk being hedged by only including firms observations with a debt-to-asset ratio of at least 20% where at least one-half of the debt is fixed rate debt. The regression results are shown in Table 8.

Given that the sub-sample considered only has 75 data points and the marginal significance of the hedging coefficient, I am reluctant to draw strong conclusions. Nevertheless, the premium for hedging the secondary interest rate risk is positive whereas for hedging the primary commodity price risk is negative. Similar to the results for commodity price risk, this result also suggests that it is unlikely that hedging causes firm value to increase.

7 Testing the Aliasing Hypothesis

In Section 5, inconsistent with the costly volatility hypothesis, I find that hedging a primary risk is associated with a discount, whereas hedging a secondary risk is associated with a significant premium. Given these findings, I now test the aliasing hypothesis. To reiterate, according to this hypothesis, the apparent valuation effects of hedging are simply because hedging is a proxy for other factors that affect firm value. To test this hypothesis, I identify a potential set of factors and then examine whether the hedging variables are still significant in explaining firm value once I also control for these factors in the firm value regressions.

7.1 Potential Omitted Variables

While there are several common drivers for hedging policy and firm value, I examine whether agency conflicts between managers and shareholders and managerial performance are potential omitted variables that correlate hedging and firm value. Several recent papers document the importance of agency conflicts on shareholder value. For example, Lemmon and Lins (2003) examine how firm values changed during the Asian financial crisis using a sample of 800 firms in eight East Asian countries. They find that Tobin's Q for firms with minority shareholders most subject to expropriation declined by twelve percent more than other firms.[17]

I construct two variables to proxy for agency costs. The first variable is the Low Entrenchment dummy based on the Gompers-Ishii-Metrick index of shareholder rights. Their sample consists of 1,500+ firms covered by the Investor Responsibility Research Center (IRRC), which covers firms that are likely to be of interest to institutional investors. Gompers et al. (2003) construct their index based on the absence or presence of 24 different corporate governance provisions that determine the balance of power in a firm between managers and shareholders. These include features specific to the firm, such as whether the firm has a staggered board, as well as features that depend on the State of incorporation, such as the State's anti-takeover laws. Their index equals the number of governance provisions that makes managers more powerful relative to shareholders. A larger value of the index is interpreted to mean that managers are more entrenched against the threat of a hostile takeover and therefore have lower incentives to increase shareholder value. They show that firms in bottom decile of their index outperform those in the top decile by an average of 8.5% per year, and that their Q values are higher. I set my Low Entrenchment

[17]Other recent papers that examine the importance of corporate governance on firm value include Hartzell and Starks (2003), Claessens et al. (2002), Himmelberg et al. (1999) and Denis and McConnell (2003).

dummy equal to unity if a firm is covered by the IRRC and is in the bottom decile of the Gompers-Ishii-Metrick index. For firms in this category, managers are the least entrenched. Therefore, they will be actively working in the interests of the shareholders to ensure that their firm does not become a takeover target, and the current management replaced by representatives of the new owners.

The second variable is based on the ownership structure of the firm. If management owns a significant portion of the company, its incentives will be better aligned with that of outside shareholders, resulting in low agency conflicts and therefore higher firm value. Similarly, institutional investors are more likely to monitor management and ensure they work in the interests of the shareholders. In keeping with the spirit of the Gompers et al. index, I construct my second proxy for agency costs by simply summing up the fraction of common stock held by insiders and institutional investors, and refer to it as the Active Shareholder index.[18]

I construct two indexes to proxy for managerial skill. The first index is developed specifically for the pure-play firms. It is based on the proposition that firms with superior operational talent will be more productive, and will have developed their reserves at lower cost. I use the ratio of quantity of annual commodity production to total assets as a measure of productivity and the ratio of proved reserves to total assets as a proxy for average costs of developing reserves. Higher values of both variables are interpreted to mean that the firm is operated more efficiently. I then form an Operating Efficiency index by normalizing each variable by its mean and then summing the normalized values.

The second index is developed for the entire sample. Analogous to the Operating Efficiency index, I construct a Financing Efficiency index to proxy for the CFO's skills. The index is based on how optimal is the capital structure of the firm from

[18]My results are qualitatively similar if I first normalize each ownership fraction by its mean before summing, or if I separately control for insider and institutional ownership.

the perspective of the trade-off theory. According to this theory, a firm's optimal leverage is chosen as the balance between the tax benefits of interest payments and the costs of bankruptcy. Hence, *ceteris paribus*, an optimally levered firm will have a high leverage ratio only if its interest payments will shield taxable profits. I use deferred tax liabilities normalized by total assets as a proxy for the likelihood of the firm being able to actually use its debt tax shields, with provisions for a higher expected liability interpreted as a higher likelihood.[19] I first construct two variables to proxy for optimal capital structure and then follow the normalizing and summing procedure used for the other indexes to construct a single Financing Efficiency index. The first variable is the product of leverage and deferred taxes. This variable will take on high values when the firm has a large debt ratio and also anticipates having taxable income to offset the interest payments. A high value is interpreted as optimal capital structure. The second variable is a dummy set to -1 if the firm's leverage is above the sample median while deferred taxes are below the median, and zero otherwise. A negative value is interpreted to mean that the firm is overlevered in the sense that interest payments are unlikely to offset taxable income. Since the issue of optimal capital structure is an area of active debate in financial economics, I include the Financing Efficiency index as a control only after including the other controls to understand whether my conclusions crucially depend on using a control for optimal capital structure.

[19]Deferred tax liabilities is COMPUSTAT item # 74. It measures the accumulated tax deferral differences between income tax expense for financial reporting and tax purposes, principally due to timing differences. Alternate proxies for the likelihood of the firm actually utilizing its debt tax shields include Graham's simulated marginal tax rate Graham (1996), or the net operating loss (NOL) carryforwards. Unfortunately, for a large fraction of my data set, the values of these proxies are missing. However, my measure is significantly positively correlated with Graham's marginal tax rates and significantly negatively correlated with NOL.

7.2 Effect of Controlling for Additional Factors on Hedging Premia

To evaluate whether the managerial performance and agency cost factors do in fact explain away the apparent valuation effects of hedging, I include them in the firm value regressions and compare the hedging premium with and without the inclusion of the factors.

I first examine the sub-sample of pure-play firms for which commodity price is a primary risk. For this sub-set of firms, I have two proxies for managerial skill, namely, the Operating Efficiency index and the Financing Efficiency index. Table 9 summarizes the effect of controlling for agency costs and managerial performance on the apparent hedging discount. Each of the regressions in this table is identical to the corresponding regression in Table 5, except for the additional controls used. I report the β and p-value for the primary risk hedged and for the additional controls. Panel A reproduces the results from Table 5. In Panel B, I summarize the regression results after controlling for operating efficiency. This factor alone reduces the apparent hedging discount by about 35%. In Panel C, I also control for agency costs using the Active Shareholder index. The decrease in the discount is now about 60%. Including the financing efficiency proxy virtually eliminates the apparent discount, with the total reduction being on the order of 80 - 90%. In unreported results, I also control for agency costs using the Low Entrenchment dummy. Although the regression coefficient on this control is significantly positive, its inclusion has a negligible impact on the apparent discount for hedging primary risk. In all the regressions, the coefficients on the controls are highly significant, and the coefficients are economically plausible. For example, the coefficient on the Operating Efficiency index is 0.088. The interquartile range of this index is 0.62, implying that a firm in the top quartile of operating efficiency trades at a premium of about 5% relative to a firm in the bottom quartile.

Next, I repeat the regressions for the full sample after including the controls for agency costs and managerial performance. The regression results are summarized in Table 10. Since I have already shown how the discount associated with hedging primary risk disappears after including the additional controls, I now focus on the secondary risk premium. The regressions are identical to those in Table 6, except for the added controls. Panel A reproduces the results from Table 6. In Panel B, I summarize the regression results with the Low Entrenchment dummy included as a control. The magnitude of the hedging premium decreases by 40+% and the proxy for hedging secondary risk is no longer significant. Additionally controlling for agency conflicts using the Active Shareholder index results in an additional modest decrease in the premium, as seen in Panel C. After controlling for agency costs, the reduction in the apparent premium for hedging secondary risk decreases by 50+%. In Panel D, I also control for managerial skill using the Financing Efficiency index, which results in an additional 15 - 20% decrease in the premium.

The results in Table 9 and 10 are consistent with the aliasing hypothesis. Hedging appears to affect firm value simply because hedging is a noisy proxy for factors not previously considered in the risk management literature that affect firm value. With the inclusion of these factors, the magnitudes of the valuation effects attributed to hedging are considerably reduced and hedging is no longer a significant explanatory variable for firm value.

Why might managerial skill and agency conflicts correlate hedging policy and firm value? First consider the apparent discount for hedging primary risk. In firms with high agency conflicts between managers and shareholders, the managers might be engaging in a variety of value-destroying activities. In an extractive industry, investment opportunities are likely to be correlated with commodity prices. So, the primary motivation for managers to hedge might not be to avoid the costs associated with raising external funding for positive NPV projects. Rather, they might be hedging to ensure sufficient funds are available for their pet projects, as suggested by Tufano (1998). Alternately, as suggested by Novaes and Zingales (1995), these managers might be entrenched and bankruptcy might be the only mechanism through which they can be replaced. By hedging the primary risk, managers of such firms might be delaying the inevitable bankruptcy to prolong the tenure of their positions.

Now consider the premium for hedging secondary risk. Brown (2001) suggests that firms hedge secondary risks as a disciplinary mechanism. Entering into actual hedge positions ensures that line managers are using real market data, as opposed to their own preferred estimates, for budgeting and planning. Since firms with good corporate governance are more likely to have such internal auditing structures in place, hedging secondary risks and good governance are positively correlated. Alternately, good managers might hedge secondary risks to reduce the noise in the firm's earnings to signal their superior abilities to the market, as suggested by DeMarzo and Duffie (1995). If hedging secondary risk is a proxy for good management – that is the real cause of higher firm value – such hedging will appear to significantly increase firm value even if the actual economic impact on the firm's financial position is negligible.

Regardless of the mechanism through which hedging policy and managerial performance or agency costs are linked, the empirical evidence is that controlling for these factors results in a significant decrease in the magnitude of the valuation effect attributed to hedging. To demonstrate that the factors I find significant in explaining away the hedging premia do indeed have explanatory power for the firm's hedging policy, I estimate a Tobit model of the fraction of production hedged as a robustness check. Table 11 shows the results for the sub-sample of pure-play firms. Model 1 is the base model. As explanatory variables, it uses proxies for firm characteristics considered important in the extant literature such as: liquidity, financing constraint, growth options, and leverage.[20] In Model 2, I also use the Operating Efficiency, Ac-

[20]See Haushalter (2000), Graham and Rogers (2002), or Purnanandam (2003) for discussions on

tive Shareholder and Financing Efficiency indexes as explanatory variables. Each of these additional explanatory variables is significant and with the expected sign. The results are consistent with the hypothesis that firms with better governance and/or better performance hedge less of their primary risk. With these additional explanatory variables, the pseudo-R^2 increases from 0.17 to 0.24, a substantial increase of 41%.

Next, I estimate a Tobit model for the fraction of production hedged using the entire sample. Recall that commodity price risk is a primary risk for some firms and a secondary risk for others. To understand how agency costs and managerial performance are related to hedging primary versus secondary risks, I interact my proxies for these factors with the classification functions described in Section 5.2. That is, I estimate a model of the form:

$$\begin{aligned} production\ hedged = &\beta_1 * entrenched * f_p + \beta_2 * entrenched * f_s + \\ &\beta_3 * active\ shareholders * f_p + \beta_4 * active\ shareholders * f_s + \\ &\beta_5 * financing\ efficiency * f_p + \beta_6 * financing\ efficiency * f_s + \\ &\beta_X * X + \varepsilon \end{aligned} \tag{6}$$

Where, *entrenched* is the Low Entrenchment dummy, *active shareholders* is the Active Shareholders index, *financing efficiency* the Financing Efficiency index, and f_p and f_s are the classification functions used to classify the extent to which the risk is a primary or secondary risk, and X are a set of control variables. Using these interaction terms, I can examine how each factor affects the decision to hedge primary and secondary risks. The explanatory variables are formed by interacting the original

the theoretical motivations.

variables with f_s or f_p. Consequently, several of them are strongly correlated, as seen in Table 12. Attempting to include all explanatory variables at once in the estimation results in the usual problems with collinear regressors. To work around this problem, I split up the explanatory variables into two sets with the elements in each set having a low degree of mutual correlation, and then estimate a Tobit model using only one set at a time. The results are shown in Table 13. Model 1 is the base regression. Models 2 and 3 include the interaction terms described above as controls. Consistent with the results in Tables 9 and 10, the Low Entrenchment dummy, which is a proxy for good external governance, is significant *only* in explaining a firm's decision to hedge *secondary* risks. The Financing Efficiency index is *positively* associated with hedging *secondary* risks, but *negatively* associated with hedging *primary* risks. These findings again highlight the differences in the motives for hedging primary versus secondary risks and are consistent with the aliasing hypothesis.

In a contemporaneous paper, Allayannis, Lel and Miller (2003) also examine whether corporate governance affects the magnitude of the "hedging premium" using an international sample of firms that hedge foreign exchange exposure. They conclude that in firms where agency costs are likely to be lower, the "hedging premium" is higher. In other words, there are "good" and "bad" hedgers, and hedging only increases firm value if performed by "good" hedgers. To examine whether this is the case in my sample, I interact my hedging variables with the governance variables. In unreported results, I find that the interaction terms are not significant.

8 Empirical versus Analytic Estimates of the Benefits of Hedging

Given the results of Sections 5 and 7, I conclude that hedging does not significantly affect firm value. As a robustness check of this conclusion, I now compare the empirically developed estimate of the increase in firm value from reducing a particular financing friction with an estimate developed from using a calibrated model.

I focus on the tax benefits of hedging, primarily because of higher debt tax shields. In a trade-of model of capital structure, a firm's optimal leverage is a balance between the costs of bankruptcy and the benefits of reduced taxes from the tax deductibility of the interest payments. *Ceteris paribus*, optimal leverage increases if the volatility of the firm's earnings decreases. Hence, hedging increases firm value by decreasing earnings volatility, leading to higher leverage and therefore higher debt tax shields.

Using a broad cross-industry sample of non-financial firms exposed to foreign currency or interest rate risk, Graham and Rogers (2002) estimate that hedging increases leverage by about 3% for a typical firm in their sample, and the associated increase in firm value is 1.1%. Their measure of hedging is the use of interest rate and forex derivatives, and basis swaps. Since the risks they consider are secondary risks, it is not clear whether hedging such risks can have such a noticeable impact on leverage.

Leland (1998) analytically examines the effect of hedging on leverage and firm value. He develops a dynamic capital structure model based on the trade-off theory and calibrates the model to be representative of a 'typical' S&P 500 firm. Using this calibrated model, he examines how firm value changes if the volatility is decreased. Leland uses the value of the unlevered firm as the state variable in his model, and reports his hedge positions in terms of a reduction in volatility of the unlevered firm. In order to express the hedge positions in more conventional units, I re-cast the model in terms of EBIT and for pedagogical purposes assume that EBIT is proportional to revenues. The main findings are presented here, and additional details are provided in Appendix A for the interested reader. Based on Leland's model, to increase firm value by 1.1% – the empirically derived estimate of the hedging benefit – the required hedge position is five times annual revenues. Clearly, the size of the hedge position estimated depends upon the modelling assumptions. However, it is an order of magnitude larger than hedge positions observed in practice. For example, in my sample, I find that the average fraction hedged is only on the order of 30% of annual production amongst the pure-play firms that hedge any of their production. For this level of hedging, the value of increased tax shields will only be on the order of 0.1% of firm value, which is an order of magnitude lower than the empirical estimate. Note that the analytic estimate is developed implicitly assuming that the firm hedges its primary risk. If a firm relies on hedging secondary risks to increase debt capacity, the estimated increase in firm value will be smaller still.

For hedging to affect debt capacity, a firm must hedge its *value*. Typically, a firm's value is several multiples of its annual earnings and its earnings shocks are persistent. Therefore, to hedge its value, the firm must hedge its earnings for several years. This requires a hedge position that is several multiples of annual revenues. Conversely, a position on the order of annual revenues will only result in a modest decrease in firm value volatility.

The results of Sections 5 and 7 are consistent with the conclusion that hedging does not significantly increase firm value. Comparing the empirical and analytic estimates of the increase in firm value by hedging because of reducing a specific friction further support this conclusion.

9 Conclusion and Future Work

This article contributes to the literature by distinguishing between primary and secondary risks for a firm, and separately analyzing the valuation effects for each type of risk. I use a sample of oil and gas producing firms, and classify commodity price volatility as a primary or secondary risk for a firm based on its E&P revenues.

I examine whether hedging causes firm value to markedly increase by examining whether the hedging premium is larger for firms that hedge a primary versus a secondary risk, as implied by theories that suggest hedging increases firm value by reducing the deadweight costs caused by cash flow volatility. I find results that are not consistent with the hedging-increases-firm value hypothesis. Specifically, I find that firms which hedge their primary risk trade at a *discount* compared to their unhedged counterparts, while firms that hedge a secondary risk trade at a significant *premium*. The data suggests that the observed effects of hedging on firm value is because hedging is a proxy for other factors which drive firm value. Consistent with the aliasing hypothesis, I find that hedging secondary risk is a proxy for low shareholder-manager agency conflicts, whereas hedging primary risk is a proxy for poor management and high agency costs between management and shareholders. Once I control for these factors, the valuation effects associated with hedging are markedly reduced. Further, using a calibrated model to estimate the increase in firm value by hedging suggests that improbably large hedge positions are required to generate hedging premiums comparable to empirical estimates. Taken together, these results suggest a need to re-examine the conclusions in the extant literature that hedging can markedly increase firm value.

While the results of this paper are persuasive, they come with the caveat that my sample consists only of firms in the oil and gas industry. Hence one must be cautious in applying these results to the entire universe of firms. Examining whether the hedging premium is a proxy for other factors in a broad cross-industry sample will help shed light on this important issue and is a topic for future exploration. Further, if hedging only has a modest impact on firm value, an interesting question for future research is whether factors unrelated to frictional costs are the primary drivers for a firm's hedging policy.

A Calculation Details for Analytic Estimates of the Effect of Hedging on Value and Stock Price Volatility

Leland (1998) develops a model of dynamic optimal capital structure, where the firm's leverage is chosen as the optimal trade-off between the benefits of debt tax shields and the bankruptcy costs. He uses the value of the unlevered firm, denoted as V, as the state variable in his analysis, which he assumes is a GBM and calibrates the process for V to match the characteristics of a typical S&P 500 firm. He estimates the bankruptcy costs using the different estimates reported in the literature. Using this calibrated model, he then estimates the change in firm value for different reductions in the volatility of the firm value process, which are reported on page 1235 of his paper. To compute the actual hedge position required to accomplish this decrease in firm value volatility, I make two assumptions. First, I assume that V is the present value of the EBIT for the firm. The EBIT process is also a GBM, with the parameters chosen to replicate the dynamics of V. Second, I assume that EBIT is proportional to revenues, so that a decrease in the volatility of revenues results in a proportional decrease in the volatility of the EBIT process. These assumptions correspond to the case of E&P firms, where commodity price risk is the main source of volatility, and hedge positions are typically reported as a fraction of anticipated next year's revenues (or production).

The key model parameters are:

- $\sigma_{EBIT} = \sigma_V = 0.2$
- riskless discount rate, $r = 0.06$
- $\delta = \frac{EBIT}{V} = 0.05$

- μ = growth rate of EBIT = $r - \delta = 0.01$

The increase in firm value for different reductions in σ_V reported by him are:

- σ_V reduced to 0.15, increase in firm value = 1.46%

- σ_V reduced to 0.10, increase in firm value = 3.77%

Since $\frac{EBIT}{V} = 0.05$, $V = 20 * EBIT$. Hence, to hedge the entire firm value, would require taking a short position equal to 20 times annual revenues. To reduce firm value volatility from $\sigma_V = 0.2$ to $\sigma_V = 0.15$, requires taking a short position equal to 5 times revenues. Graham and Rogers (2002) estimate an increase in firm value because of increase debt shields of 1.1%. To generate such an increase would require a short position of approximately 4 times annual revenues. In contrast, typical hedge positions are much smaller. As seen in Table 14, even for commodity producers who have the ability to hedge away much of the volatility in their earnings, the median fraction of estimated annual production (or revenues) hedged is less than unity, and the corresponding increase in firm value will be well below 1%.

Table 14: Hedge Positions as Multiples of Annual Production

Table 14 summarizes typical hedge positions for firms in different extractive industries.

Commodity Produced	Median (entire sample)	Mean (hedgers only)	Max	Sample Period	Data Source
Gold	0.69	0.90	2.67	1991 - 1993	Tufano (1996)
Gold	0.38	N.A.	N.A.	1989 - 1998	Adam (2002)
Oil and gas	0.23	0.35	1.00	1999 - 2000	my sample
Oil and gas	0.00	0.29	0.98	1992 - 1994	Haushalter (2000)

The oil and gas data is collected only for hedging positions one year into the future, hence the maximum reported is biased downwards. However, few firms hedge production two or more years into the future. Furthermore, the fraction of production hedged two or more years into the future tends to be small compared to the one year ahead position. Hence, the bias in central statistics, such as the mean and medians should be small.

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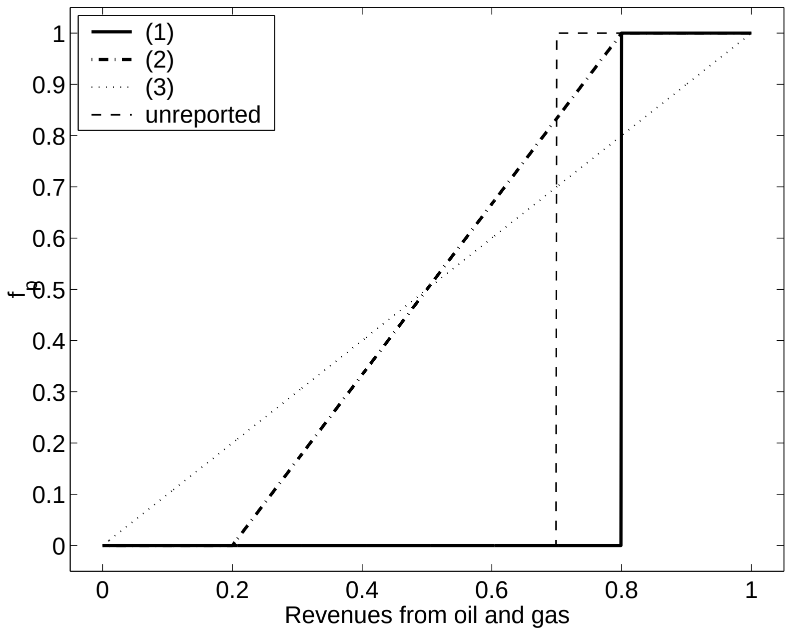
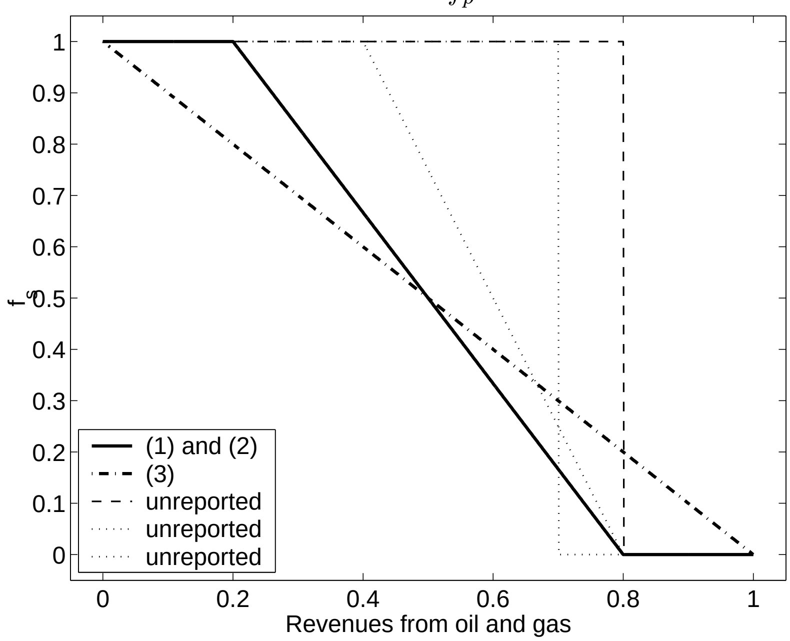
Figure 1: Plots for f_p and f_s

Figure 1 plots the different classification functions used to classify commodity price as a primary or secondary risk, based on the fraction of revenues derived from commodity sales. These functions are used to construct the proxies for primary and secondary risk hedged, $hedge_p$ and $hedge_s$, respectively. The plots labelled (1), (2) and (3), are the functions used for the corresponding regressions shown in Table 6.



Panel A: f_p



Panel B: f_s

Table 1: Changes in Financial Condition because of Changes in Primary versus Secondary Risks

Table 1 compares how the financial condition of two firms changes with a change in commodity prices. *Revenues from E&P* is the fraction of total revenues derived from oil and gas produced by the firm's exploration and production business segment. Commodity price risk is classified as a primary risk if at least 80% of total revenue is from the E&P segment.

Company Name	Mission Resources	Resource America
Revenues from E&P (%)	100%	18%
Classification of commodity price risk	Primary	Secondary
1999 cash flow from operations ($MM)	38.8	7.8
2000 cash flow from operations ($MM)	61.6	8.6
Increase (%)	**59**	**10**
1999 net income ($MM)	8.8	18.4
2000 net income ($MM)	32.2	18.1
Increase(%)	**266**	**-1.6**

Table 2: Control Variables

General Firm Characteristics	
Total assets	Book value of total assets ($MM)
Pretax ROA	Ratio of earnings before extraordinary items scaled by total assets (A measure of profitability)
E&P revenues	Fraction of total revenues derived from commodity production
Leverage	Sum of long-term and current debt normalized by sum of long-term debt, current debt and shareholder's equity (book values)
Ratings index	Equals +1 for firms with a rating of BBB or better, −1 for firms rated CCC or below, and is zero for unrated firms or for firms with ratings between CCC+ and BBB-
Oil and gas revenues	Fraction of total revenues derived from oil and gas production
Financing Constraints	
Dividend dummy	Equals one if the firm pays dividends to common shareholders
KZ index	Modified Kaplan-Zingales Index = -1.002 * cash flow - 39.368 * dividends -1.315 * cash + 3.139* leverage.
Growth Options	
Capital expenses/assets	Capital expenditures scaled by total assets
Capital expenses/sales	Capital expenditures scaled by net sales
Agency Costs	
Insider ownership	Fraction of common stock held by managers or directors
Institutional ownership	Fraction of common stock held by institutions
Not entrenched dummy	Equals one if the Gompers-Ishii-Metrick corporate governance index for the firm is in the lowest decile

I use modified KZ index as proposed by Baker et al. (2002). The individual terms are defined as: *cash flow*= (income before extraordinary items + depreciation and amortization)/total assets *dividends* = (dividends from common stock + dividends from preferred stock)/total assets *cash* = (cash and short term investments)/total assets *leverage* = (long term debt + debt in current liabilities)/(long term debt + debt in current liabilities + total stockholders equity)

Table 3: Summary Statistics

Variable	N	Mean	Std. Dev.	5th %ile	Median	95th %ile
Panel A - Full Sample						
log(Tobin's Q)	364	0.322	0.332	-0.157	0.286	0.911
Production hedged	364	0.222	0.243	0	0.144	0.731
Total assets	364	1349	3575	29.9	239.3	5899
Leverage	364	0.434	0.304	0	0.446	0.852
Oil and gas revenues	364	0.873	0.25	0.23	1	1
KZ index	364	0.763	1.397	-1.379	0.858	2.598
Capital expenses/assets	354	0.199	0.134	0.0385	0.172	0.461
Pretax ROA	364	0.0182	0.104	-0.149	0.0243	0.145
Not entrenched dummy	364	0.066	0.249	0	0	1
Insider ownership	364	0.127	0.169	0	0.058	0.540
Institutional ownership	364	0.372	0.236	0.015	0.358	0.762
Panel B - Sub-Sample of Pure-Play Firms						
log(Tobin's Q)	294	0.354	0.327	-0.132	0.329	0.921
Production hedged	294	0.239	0.251	0	0.155	0.759
Total assets	294	703	1408	28.96	187.8	3294
Leverage	294	0.432	0.327	0	0.442	0.912
Oil and gas revenues	294	0.984	0.046	0.84	1	1
KZ index	294	0.804	1.476	-1.59	0.897	2.706
Capital expenses/assets	285	0.217	0.138	0.041	0.191	0.477
Pretax ROA	294	0.0163	0.113	-0.155	0.0238	0.146
Not entrenched dummy	294	0.0442	0.206	0	0	0
Insider ownership	294	0.119	0.155	0	0.061	0.460
Institutional ownership	294	0.363	0.237	0.012	0.332	0.771
Panel C - Sub-Sample of Diversified Firms						
log(Tobin's Q)	70	0.185	0.321	-0.173	0.201	0.519
Production hedged	70	0.151	0.192	0	0.0625	0.493
Total assets	70	4065	7041	34.8	1254	19414
Leverage	70	0.445	0.178	0.089	0.457	0.715
Oil and gas revenues	70	0.404	0.209	0.12	0.38	0.75
KZ index	70	0.591	0.989	-0.945	0.713	2.179
Capital expenses/assets	69	0.126	0.0833	0.030	0.111	0.363
Pretax ROA	70	0.026	0.053	-0.045	0.0245	0.128
Not entrenched dummy	70	0.157	0.367	0	0	1
Insider ownership	70	0.161	0.213	0	0.030	0.631
Institutional ownership	70	0.412	0.231	0.018	0.442	0.741

Table 4: Comparison of Q values for Non-Hedgers versus Hedgers

Table 4 compares the mean values of hedgers versus non-hedgers for the sub-samples of pure-play and diversified firms. The non-hedgers are defined as firm-years with none of next year's production hedged, and the hedgers as the complement. Firm-years with a positive but trivial amount (<2%) of hedging are excluded. Firms are classified as pure-play firms if at least 80% of revenues is derived from the E&P segment, and as diversified firms otherwise. The *p*-value in Panel A is calculated assuming equal conditional variances and in panel B assuming unequal variances since the equal variance assumption is rejected at the 10% significance level.

Variable: ln(Q)	Non-hedgers (1)	Hedgers (2)	Δ =(2) - (1)	t-stat	*p*-value
	Panel A: Pure-play firms – hedging primary risk				
Mean	0.435	0.313	-0.123	-2.89	0.004
SD	0.363	0.305			
N	81	202			
	Panel B: Diversified firms – hedging secondary risk				
Mean	0.031	0.283	0.252	2.80	0.009
SD	0.413	0.223			
N	25	41			

Table 5: Premium for Hedging Primary Risk – Sub-sample of Pure-Play E&P Firms
Table 5 shows the results for regressing Tobin's Q on the fraction of commodity price risk hedged in the sub-sample of pure-play firms. *Production hedged* is the fraction of next year's production hedged against a fall in commodity prices. The p-values are calculated using Newey-West standard errors. See Table 2 for definitions of the control variables. Values for the intercept and year dummies have not been shown to save space.

	(1)		(2)		(3)	
	β	p-value	β	p-value	β	p-value
	Dependent variable: log(Tobin's Q)					
Production hedged	-0.171	0.021	-0.163	0.035	-0.171	0.025
KZ index	-0.020	0.013			-0.038	0.030
Dividends dummy			0.049	0.330		
Capital expenses/assets	0.243	0.001	0.480	0.001		
Capital expenses/sales					0.035	0.055
Pretax ROA	0.161	0.088	0.269	0.150	0.409	0.047
Log(assets)	0.009	0.313	0.017	0.348	0.019	0.304
Ratings index	0.031	0.227	0.045	0.391	0.047	0.379
Leverage	0.030	0.555	-0.073	0.382	0.052	0.626
E&P revenues	0.191	0.337	0.369	0.375	0.396	0.333
N	285		285		285	
R^2	0.212		0.202		0.181	

Table 6: Premia for Hedging Primary and Secondary Risks - Full Sample

Table 6 shows the regression results for Tobin's Q on proxies for hedging primary and secondary risks. $hedge_p$ and $hedge_s$ are the proxies for hedging primary and secondary risks, respectively and f_p and f_s are the functions used to classify commodity price risk as a primary or secondary risk. The regressions use different definitions of f_p and f_s. See the text for how these proxies and classification functions are constructed. f_p and f_s are included as controls in regression (1); f_s is dropped for (2) since it is collinear with f_p, and both, f_p and f_s are dropped for (3) since they are collinear with E&P revenues. The p-values are calculated using Newey-West standard errors. See Table 2 for definitions of the control variables. Values for the intercept and year dummies have not been shown to save space.

	(1)		(2)		(3)	
	β	p-value	β	p-value	β	p-value
Dependent variable: log(Tobin's Q)						
$hedge_p$	-0.177	0.014	-0.162	0.027	-0.167	0.023
$hedge_s$	0.267	0.033	0.297	0.022	0.358	0.019
KZ index	-0.049	0.002	-0.045	0.004	-0.045	0.004
Capital expenses/assets	0.576	0.000	0.578	0.000	0.587	0.000
Pretax ROA	0.347	0.080	0.353	0.074	0.346	0.082
Log(assets)	0.028	0.074	0.025	0.105	0.027	0.076
Ratings index	0.075	0.091	0.070	0.107	0.060	0.163
Leverage	0.113	0.259	0.104	0.302	0.097	0.337
E&P revenues	0.231	0.535	0.689	0.047	0.427	0.000
f_p	0.232	0.077	-0.236	0.357		
f_s	0.080	0.619				
N	354		354		354	
R^2	0.259		0.248		0.246	

Table 7: Commodity Price Changes and the Hedging Premium - Sub-sample of Pure-Play Firms

Table 7 compares the mean Q values for significant hedgers versus non-hedgers during periods of rising versus falling commodity prices. *Significant hedgers* are firm-years that hedge at least 30% of their production for the following year. *Non-hedgers* are firm-years that hedge none of their production for the following year. The *p*-values in Panel A are calculated assuming equal conditional variances, and in panel B assuming unequal variances since the equal variance assumption is rejected at the 10% significance level.

Dependent variable: ln(Q)	Non-hedgers (1)	Significant Hedgers (2)	$\Delta =$ (2) - (1)	t-stat	*p*-value
	Panel A: Price drop: years 1992, 1993 and 2000				
	Premium expected from mechanics of hedging				
Mean	0.491	0.375	-0.115	-1.91	0.058
SD	0.333	0.329			
N	62	59			
	Panel B: Price rise: years 1994 & 1999				
	Discount expected from mechanics of hedging				
Mean	0.347	0.188	-0.160	-1.97	0.055
SD	0.388	0.261			
N	30	43			

Table 8: Premium for Hedging Interest Rate Risk

Table 8 shows the premium associated with hedging interest rate risk in the subsample of pure-play firms. The sample only includes observations that have apriori exposure to interest rate risk, as described in the main text. The sample is from 1999 and 2000 because data for interest rate derivatives use was only collected for this period. Values for the intercept, ratings index and year dummies have not been shown to save space.

Dependent Variable: ln(Tobin's Q)	β	p-value
Interest rate swap user dummy	0.100	0.091
Pretax ROA	0.321	0.083
Log(total assets)	-0.001	0.979
Capital expenses/assets	0.926	0.001
KZ index	-0.036	0.002
Leverage	-0.205	0.267
R^2	0.459	
N	75	

Table 9: Primary Risk Hedging Discount after Controlling for Agency Costs and Managerial Performance – Sub-Sample of Pure Play Firms

Table 9 reports the coefficients for the fraction of production hedged and the proxies for managerial skills and agency costs. The regressions are identical to those in Table 5, except for the additional controls used. *Production hedged* is the fraction of next year's commodity production hedged. *Operating Efficiency* is an index constructed from the firm's production and reserves data to proxy for the efficiency of the operations. *Financing Efficiency* is an index constructed from capital structure data to proxy for the financial skills of management. See the body of the text for details on how the indexes are constructed. *Active Shareholders* is the sum of common shares owned by insiders and institutional investors. *Decrease* is the reduction in the magnitude of the apparent hedging discount after including the additional controls for firm value. The p-values are calculated using Newey-West standard errors.

	(1)		(2)		(3)	
Dependent Variable: ln(Tobin's Q)	β	p-value	β	p-value	β	p-value
Panel A – Original model (from Table 5)						
Production hedged	-0.171	0.021	-0.163	0.035	-0.171	0.025
Panel B - Include control for operating efficiency						
Production hedged	-0.103	0.134	-0.096	0.177	-0.096	0.164
Operating Efficiency	0.095	0.005	0.100	0.003	0.115	0.002
Decrease (%)	40		41		44	
Panel C - Include controls for operating efficiency and agency costs						
Production hedged	-0.067	0.334	-0.064	0.374	-0.064	0.361
Operating Efficiency	0.088	0.008	0.097	0.004	0.105	0.003
Active Shareholders	0.254	0.001	0.234	0.004	0.253	0.002
Decrease (%)	61		61		63	
Panel D - Include controls for operating and financing efficiency and agency costs						
Production hedged	-0.013	0.847	-0.013	0.857	-0.011	0.872
Operating Efficiency	0.088	0.005	0.099	0.002	0.104	0.012
Financing Efficiency	0.013	0.003	0.013	0.004	0.014	0.001
Active Shareholders	0.272	0.000	0.251	0.001	0.271	0.001
Decrease (%)	92		92		94	

Table 10: Secondary Risk Hedging Premium after Controlling for Agency Costs and Managerial Performance – Full Sample

Table 10 reports the coefficients for the proxy for hedging secondary risk and the proxies for managerial skills and agency costs. The regressions are identical to those in Table 6, except for the additional controls used. $hedge_s$ is the proxy for secondary risk hedged. See the text for details. *Low Entrenchment dummy* equals unity if the Gompers et al. governance index for the firm is in the bottom decile. *Active Shareholders* is the sum of the fraction of common shares owned by insiders and institutional investors. *Financing Efficiency* is an index constructed from capital structure data to proxy for the financial skills of management. See the body of the text for details on how the indexes are constructed. *Decrease* is the reduction in the magnitude of the apparent hedging premium after including the additional controls for firm value. The p-values are calculated using Newey-West standard errors.

	(1)		(2)		(3)	
Dependent Variable: ln(Tobin's Q)	β	p-value	β	p-value	β	p-value
Panel A – Original model (from Table 6)						
$hedge_s$	0.267	0.033	0.297	0.022	0.358	0.019
Panel B - Include control for managerial entrenchment						
$hedge_s$	0.145	0.220	0.177	0.141	0.231	0.101
Low Entrenchment dummy	0.155	0.017	0.153	0.016	0.158	0.012
Decrease (%)	46		40		35	
Panel C - Include controls for agency conflicts						
$hedge_s$	0.118	0.328	0.144	0.245	0.203	0.162
Low Entrenchment dummy	0.170	0.007	0.168	0.006	0.173	0.004
Active Shareholders	0.241	0.001	0.237	0.002	0.231	0.002
Decrease (%)	56		52		43	
Panel D - Include controls for agency conflicts and financing efficiency						
$hedge_s$	0.071	0.562	0.085	0.495	0.127	0.381
Low Entrenchment dummy	0.185	0.002	0.184	0.001	0.189	0.001
Active Shareholders	0.255	0.000	0.251	0.001	0.245	0.001
Financing Efficiency	0.013	0.001	0.014	0.000	0.014	0.001
Decrease (%)	73		71		65	

Table 11: Effect of Agency Costs and Performance Measures on Hedging Policy – Pure-Play Sub-Sample

Table 11 shows results of the pooled Tobit regression of the fraction of next year's production hedged. *Model 1* contains the typical explanatory variables considered in the literature. $Leverage^2$ equals the squared value of leverage, and is included based on Purnanandam (2003). The definitions of the other control variables is provided in Table 5. *Model 2* also includes the proxies for agency costs and performance measures. The definitions of these additional control variables is provided in Table 9. The coefficients for the intercept and time dummy are not shown to conserve space. $Pseudo - R^2$ is calculated by regressing the actual fraction of production hedged on the estimated value from the Tobit model.

	Model 1		Model 2	
Explanatory variables	Slope	*p*-value	Slope	*p*-value
Dependent variable: fraction of next year's production hedged				
Operating Efficiency index			-0.058	0.067
Active Shareholder index			-0.169	0.021
Financing Efficiency index			-0.021	0.000
Cash-to-assets	-0.447	0.095	-0.380	0.153
Log(assets)	-0.023	0.229	0.000	0.987
Pretax ROA	-0.164	0.333	0.074	0.661
KZ index	0.001	0.956	0.005	0.769
Capital expenses/assets	0.056	0.683	0.123	0.350
Ratings index	-0.056	0.391	-0.033	0.598
Leverage	0.967	0.000	0.883	0.000
$Leverage^2$	-0.751	0.007	-0.784	0.004
Number of Observations	284		284	
Censored Values	79		79	
Log Likelihood	-105.5		-92.4	
$Pseudo - R^2$	0.17		0.24	

Table 12: Correlations Between Explanatory Variables for Production Hedging Model - Full Sample

Table 12 shows the correlations between the different explanatory variables used for the Tobit regressions shown in Table 13 that are formed by interacting the proxies for agency costs and managerial ability with the extent to which commodity price is a primary or a secondary risk. The terms f_p and f_s are the classification functions used for regression (1) of Table 6. *entrench* is the abbreviation used for the Low Entrenchment dummy, *active* for the Active Shareholder index, and *fin.* for the Financing Efficiency index. The p-value for each correlations is reported below the value in parentheses.

	entrench*f_p	active*f_p	fin.*f_p	entrench*f_s	active*f_s	fin.*f_s
entrench*f_p	1.000	0.017	-0.058	-0.033	-0.080	-0.062
		(0.746)	(0.268)	(0.534)	(0.129)	(0.240)
active*f_p		1.000	0.076	-0.218	-0.530	-0.411
			(0.151)	(0.000)	(0.000)	(0.000)
fin.*f_p			1.000	0.000	0.000	0.000
				(1.000)	(1.000)	(1.000)
entrench*f_s				1.000	0.531	0.567
					(0.000)	(0.000)
active*f_s					1.000	0.747
						(0.000)
fin.*f_s						1.000

Table 13: Effect of Agency Costs and Performance Measures on Hedging Policy – Full Sample

Table 13 shows the pooled Tobit regression for the fraction of production hedged. *Model 1* is the base regression, using explanatory variables identified in the extant literature. *Model 2* and *Model 3* use additional explanatory variables created by interacting the proxies for agency costs and managerial performance with the classification functions f_p and f_s used in regression (1) of Table 6. *entrench* is the abbreviation used for the Low Entrenchment dummy, *active* for the Active Shareholder index, and *fin.* for the Financing Efficiency index. See Tables 6 and 10 for descriptions of the explanatory variables.

	Model 1		Model 2		Model 3	
Explanatory variables	Slope	p-value	Slope	p-value	Slope	p-value
Dependent variable: fraction of next year's production hedged						
entrench * f_p					0.083	0.351
entrench * f_s			0.173	0.018		
active * f_p			-0.174	0.011		
active * f_s					0.183	0.376
fin. * f_p			-0.021	0.000		
fin. * f_s					0.060	0.011
Cash-to-assets	-0.506	0.039	-0.395	0.099	-0.504	0.038
Log(assets)	-0.011	0.485	0.006	0.708	-0.028	0.102
Pretax ROA	-0.119	0.459	0.044	0.781	-0.106	0.502
KZ index	0.001	0.928	0.007	0.633	0.001	0.940
Capital expenses/assets	0.058	0.652	0.090	0.460	0.081	0.526
Ratings index	-0.103	0.058	-0.077	0.146	-0.062	0.267
Leverage	1.039	0.000	0.972	0.000	1.034	0.000
$Leverage^2$	-0.838	0.001	-0.920	0.000	-0.805	0.002
E&P Revenues	0.189	0.628	0.050	0.894	0.080	0.836
f_p	0.171	0.125	0.301	0.009	0.187	0.096
f_s	0.249	0.159	0.128	0.452	0.003	0.987
N	354		354		354	
Censored Values	104		104		104	
Log Likelihood	-121.8		-107.5		-117.6	
$Pseudo-R^2$	0.19		0.26		0.21	